

# **The Hudson Bay Intracratonic Basin in Northern Canada: New Hydrocarbon System Data for an Oil-Prospective Frontier\***

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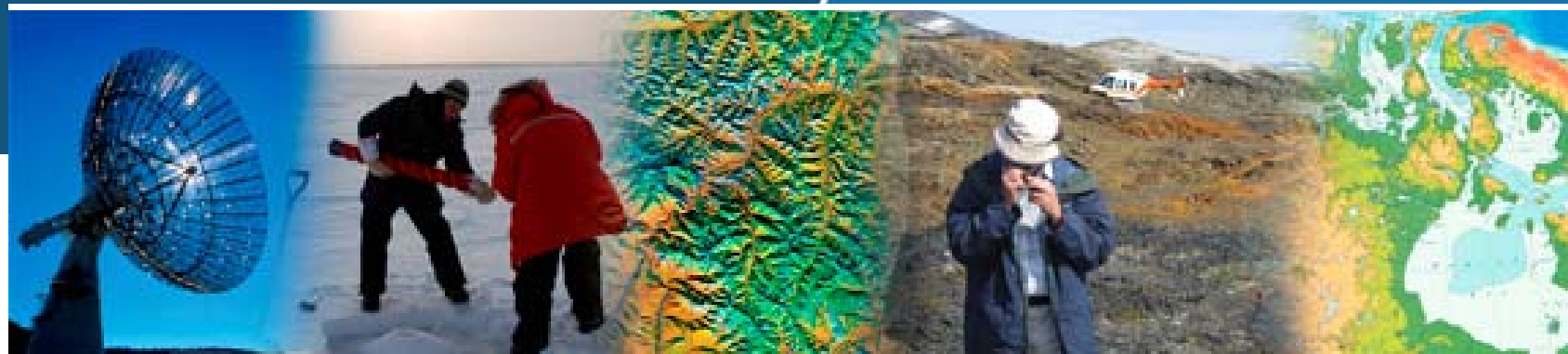
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## **Abstract**

The Hudson Platform covers 600,000 km<sup>2</sup> and is one of the largest Paleozoic sedimentary basins in Canada and the largest of the intracratonic basins in North America. The Platform contains the large Hudson Bay Basin and smaller satellite basins, namely the Moose River to the south and the Foxe to the north. The succession of the Hudson Platform consists of Ordovician to Tertiary strata, with a maximum preserved thickness of about 2500 m. The Paleozoic succession includes Ordovician to Devonian shallow marine carbonates, reefs and thin mudstones with thick Devonian evaporites. Paleozoic strata are unconformably overlain by erosional remnants of Jurassic, Cretaceous and Tertiary non-marine and marine sandstones, mudstones and lignite seams. Biostratigraphic data indicate significant unconformities and AFT and U-Th/He data allow us to refine our understanding of the burial history. The hydrocarbon potential of the Hudson Platform is poorly constrained. In a first phase of exploration (1970-1980), over 46,000 line-km of seismic reflection data were acquired and 5 exploration wells drilled. Most of the seismic profiles and all of the exploration wells are located in a relatively small area in the central part of Hudson Bay. A limited number of onshore wells have also been drilled. The

Geological Survey of Canada and its partners are carrying out a re-evaluation of the petroleum systems and energy resource potential of the Hudson Platform. Results indicate that many prospective petroleum reservoir and trap types, including recently recognized porous hydrothermal dolomites and reefs. Upper Ordovician oil shales are widespread with TOC values up to 35% (average of 15%); the thickness of these Type I/II source rocks range between 5 to 15 metres. Two Upper Ordovician stratigraphically distinct source rocks have been identified and their known presence extended over all onshore areas surrounding the marine basin. Thermal maturation data on well cuttings suggest that oil window conditions (Ro of 1%) have been reached in the intervals that host the Ordovician source rocks. New high-resolution bathymetric surveys in Hudson Bay have led to the recognition of circular sea-floor depressions similar to fluid-escape pockmarks and preliminary interpretations of RADARSAT images suggest possible local oil slicks at sea surface. New hydrocarbon systems data suggest that large areas of the Hudson Platform are prospective for oil accumulations.

# The Hudson Bay Intracratonic Basin in Northern Canada: New Hydrocarbon System Data for an Oil-Prospective Frontier Basin.



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# INTRODUCTION

**The Hudson Bay basin is the least known (unstudied) basin in the center of North America. Previous exploration round (1970's-1980's) resulted in 46 000 km of poor resolution seismic and 5 wells with minor oil and gas shows.**

**The temperature history of these basins is largely unknown, so it is not clear if oil or gas have been generated. Hudson Bay was not tested for the kinds of prolific oil and natural gas reservoirs that have been found in central USA since the first round of exploration.**



# OUTLINE

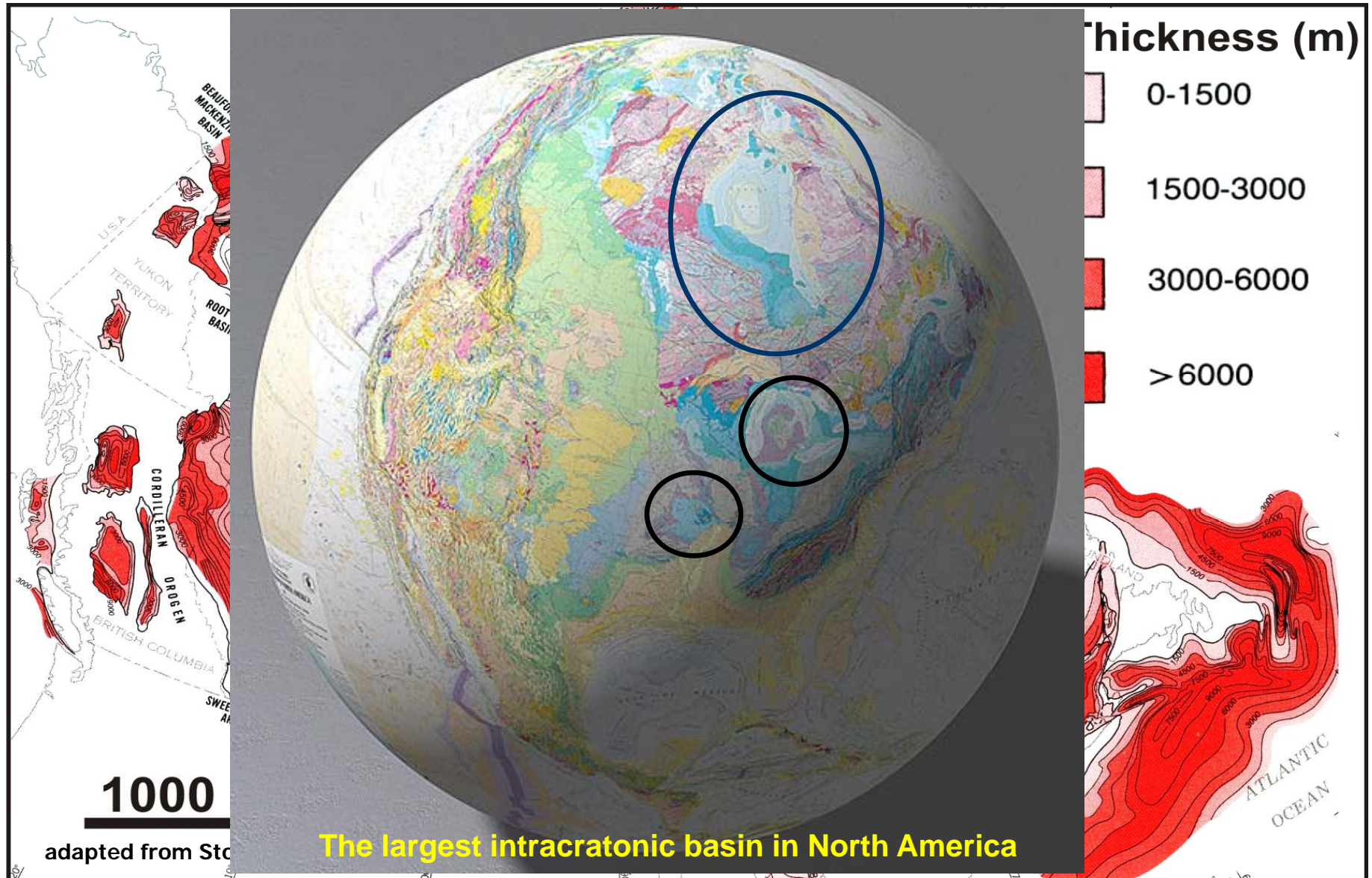
## Hudson Bay Basin

1. Geological setting and historical review
2. Stratigraphy
3. Hydrocarbon system data
  - Source rock – nature, distribution, maturity
  - Reservoir rocks – HTD and reefs
4. Evidence for active hydrocarbon systems
5. Conclusions

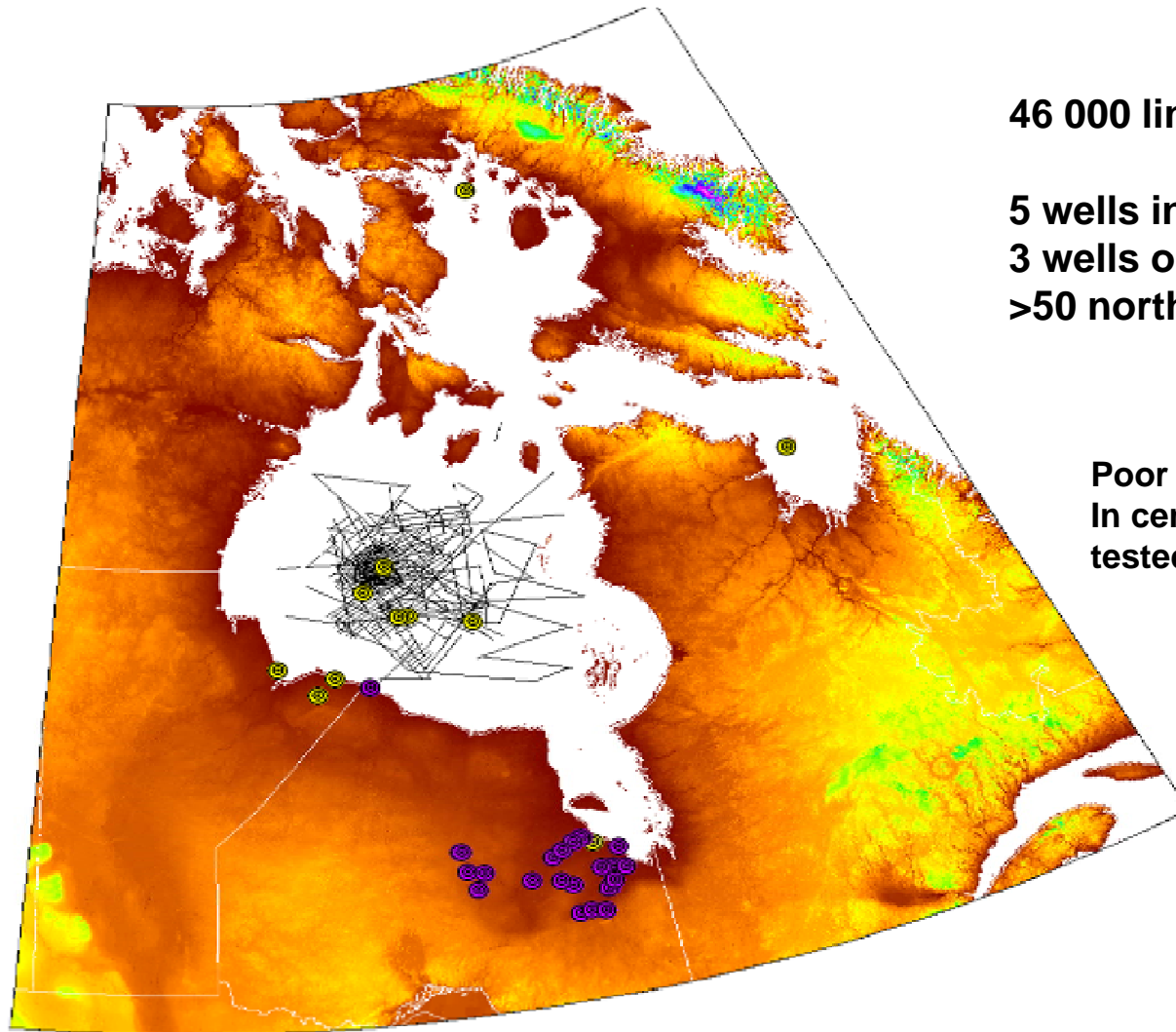


# Hudson Bay Platform

## A major FRONTIER sedimentary basin in Northern Canada



# Regional and historic background



**46 000 linear-km of seismic**

**5 wells in the Bay  
3 wells onshore Manitoba  
>50 northern Ontario**

**Poor to fair quality seismic  
In central Hudson Bay  
tested only structural highs**



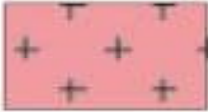
# Bedrock Geology

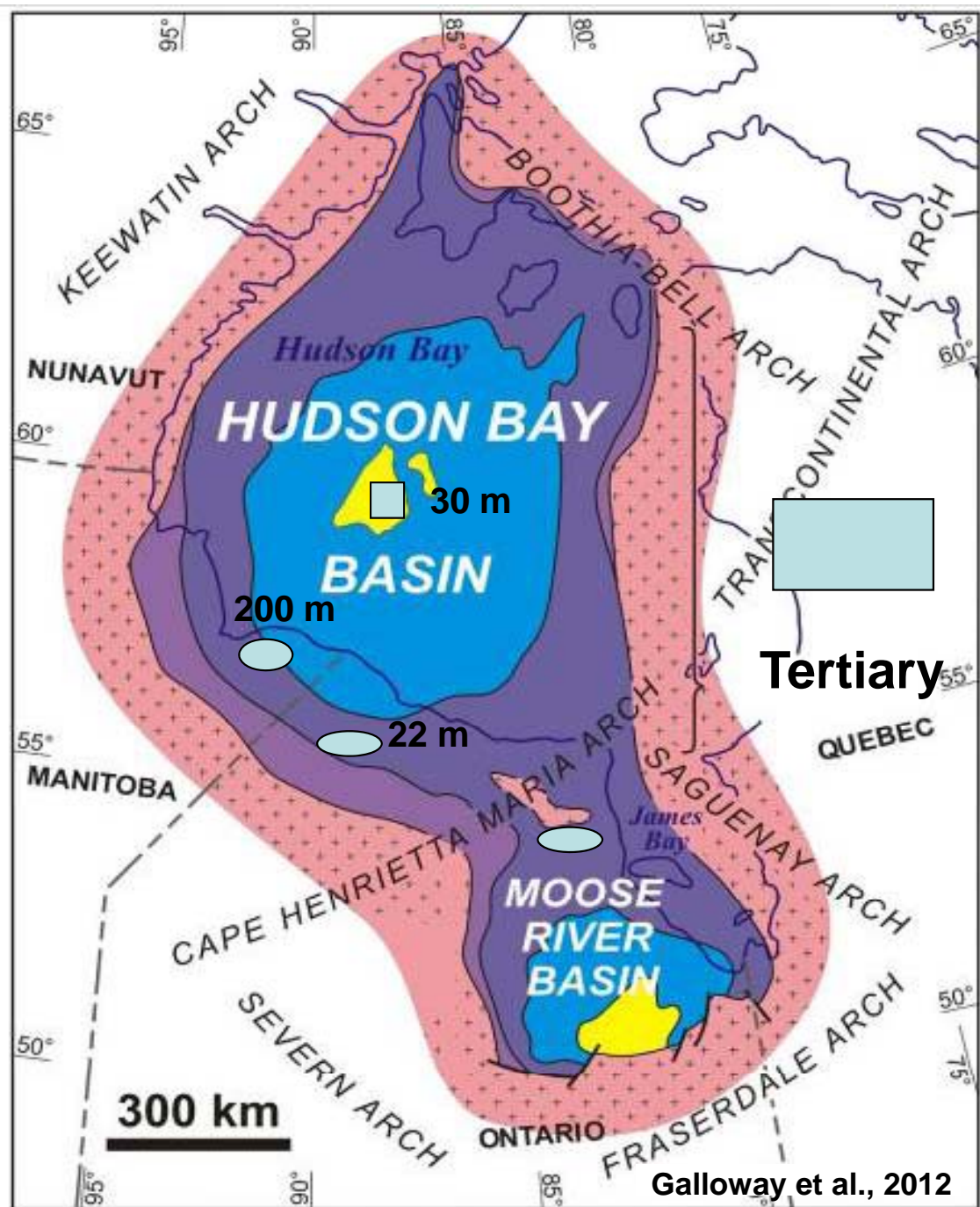
  
Jurassic/  
Cretaceous

  
Devonian

  
Silurian

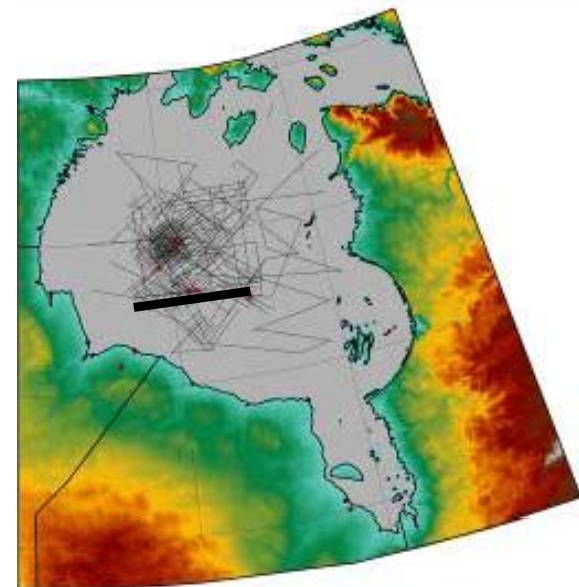
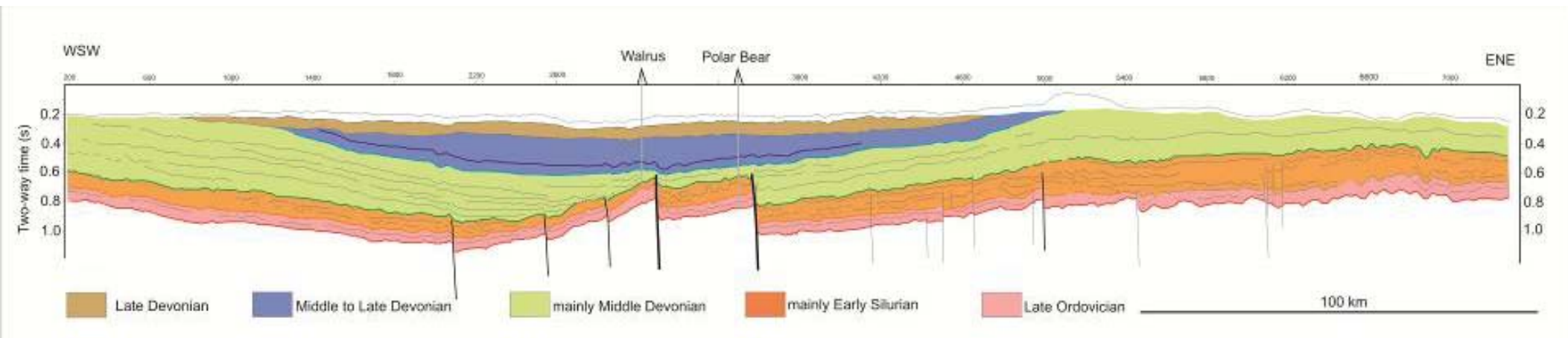
  
Ordovician

  
Precambrian

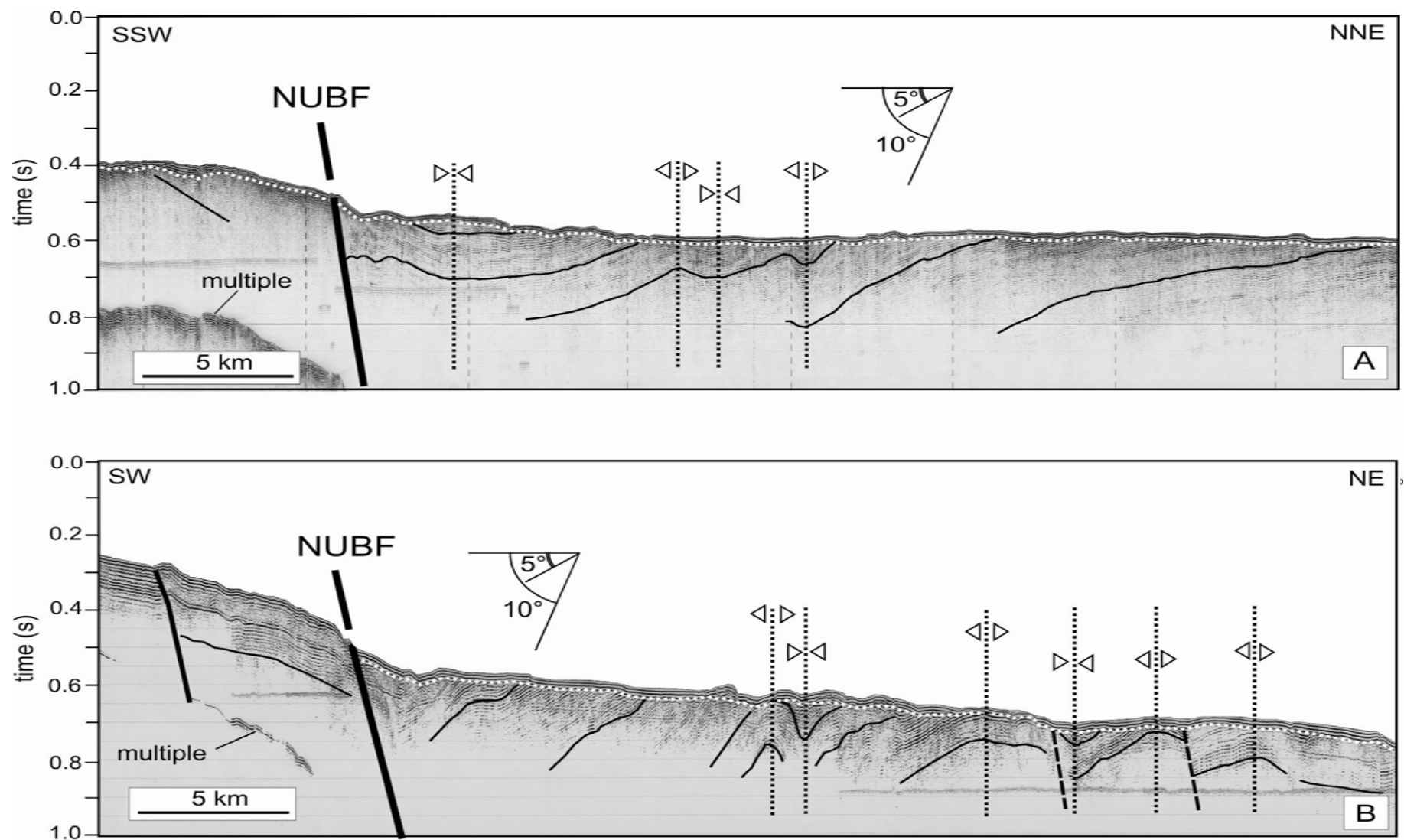


Galloway et al., 2012

# Basin geometry

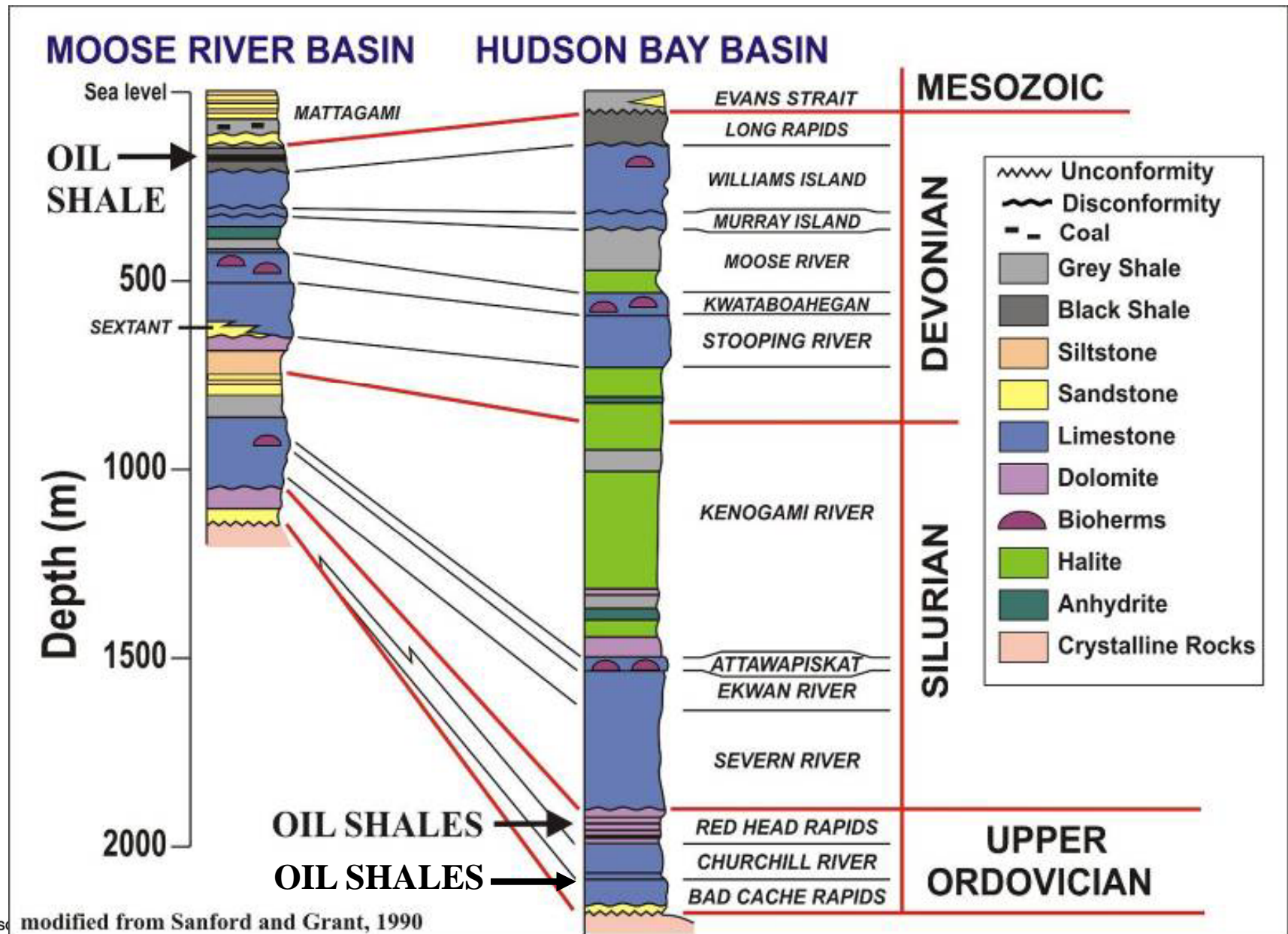


# Examples of high-res GSC seismic

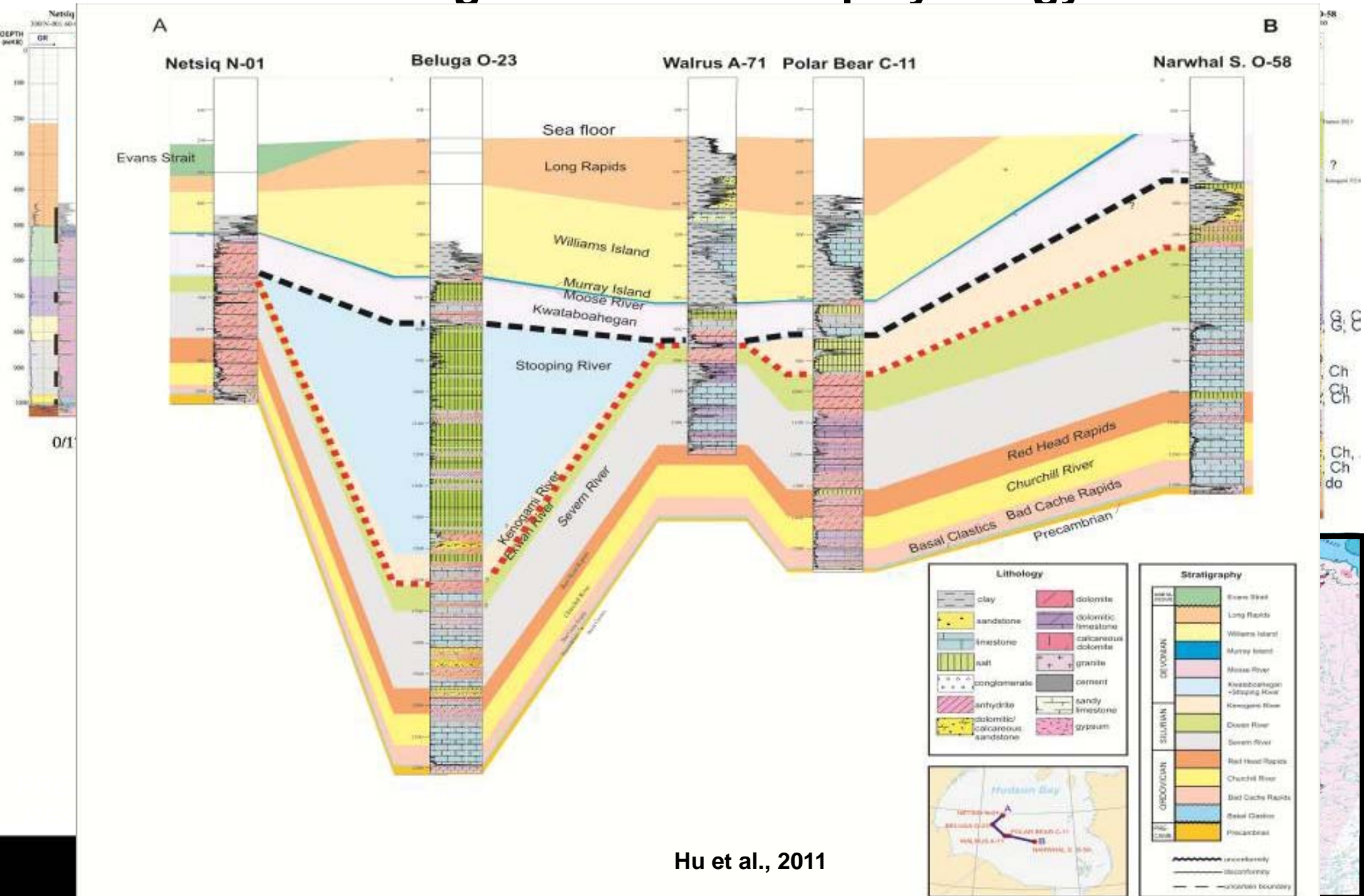


Pinet et al., Figure 11

# Carbonate platform with evaporites



# Hudson Bay - Log correlation and palynology



# HYDROCARBON SYSTEM ELEMENTS

1. SOURCE ROCKS

2. RESERVOIRS

3. TRAPS AND SEALS



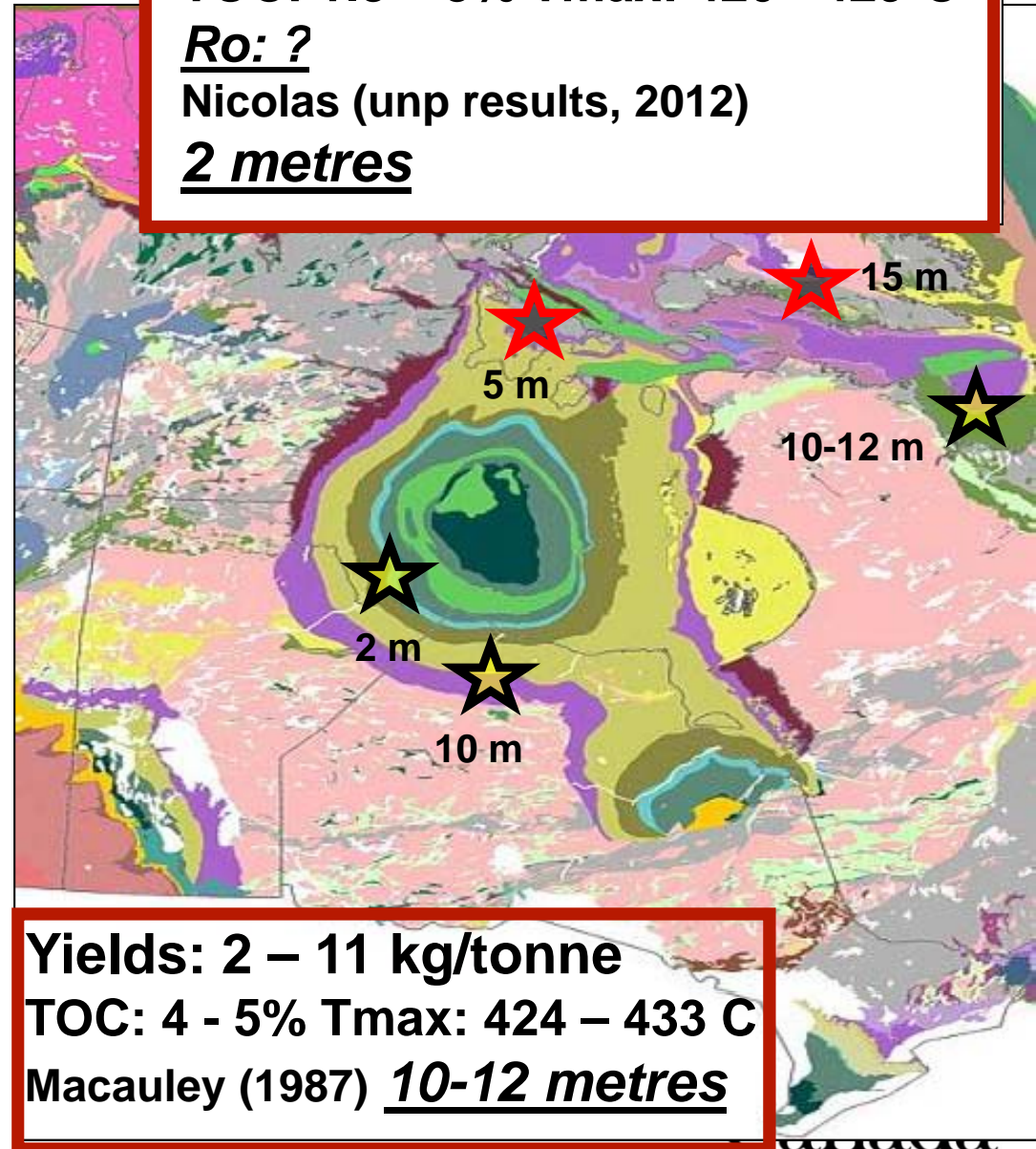
# Source rock distribution (outcrop and well data)

**Yields: 20 - 134 kg/tonne**  
**TOC: 5 - 35% Tmax: 421 - 432°C**  
**Ro: 0.4 - 0.6%**  
— Macauley (1986); Zhang (2009, 2011)

**Yields: 16 - 99 kg/tonne**  
**TOC: 3 - 15% Tmax: 416 - 431°C**  
— Macauley (1987); 10-15 metres  
— Zhang (2011): 5 m (exposed)

**Boas River shale,**  
**TOC: 3 - 15% Tmax: 420 - 426°C**  
**Ro: 0.6 - 0.8%**  
Armstrong and Lavoie (2010)  
10 metres

**Boas River shale,**  
**TOC: 1.8 - 8% Tmax: 420 - 429°C**  
**Ro: ?**  
Nicolas (unp results, 2012)  
2 metres

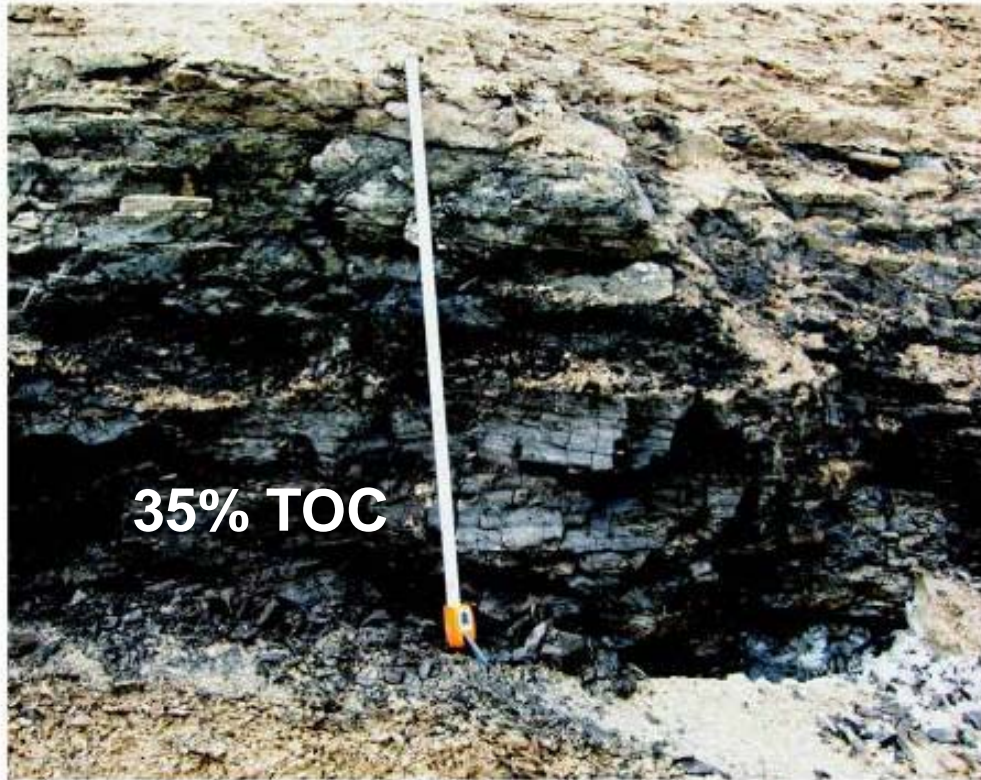


**Yields: 2 - 11 kg/tonne**  
**TOC: 4 - 5% Tmax: 424 - 433 C**  
Macauley (1987) 10-12 metres



# Ordovician source rock Southampton Island

## Lower Oil Shale



## Upper Oil Shale



*Upper Ordovician Red Head Rapids Fm.*



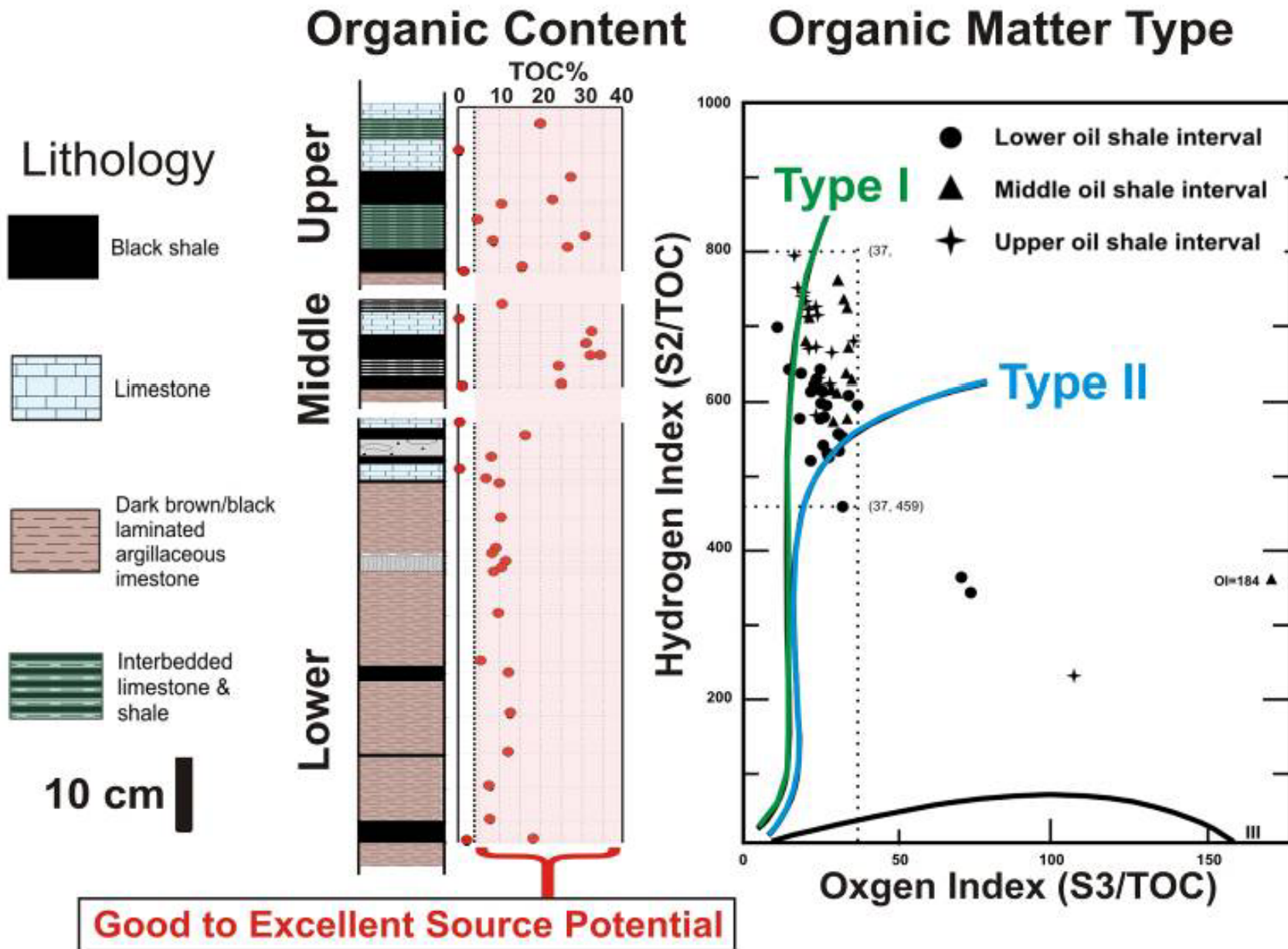
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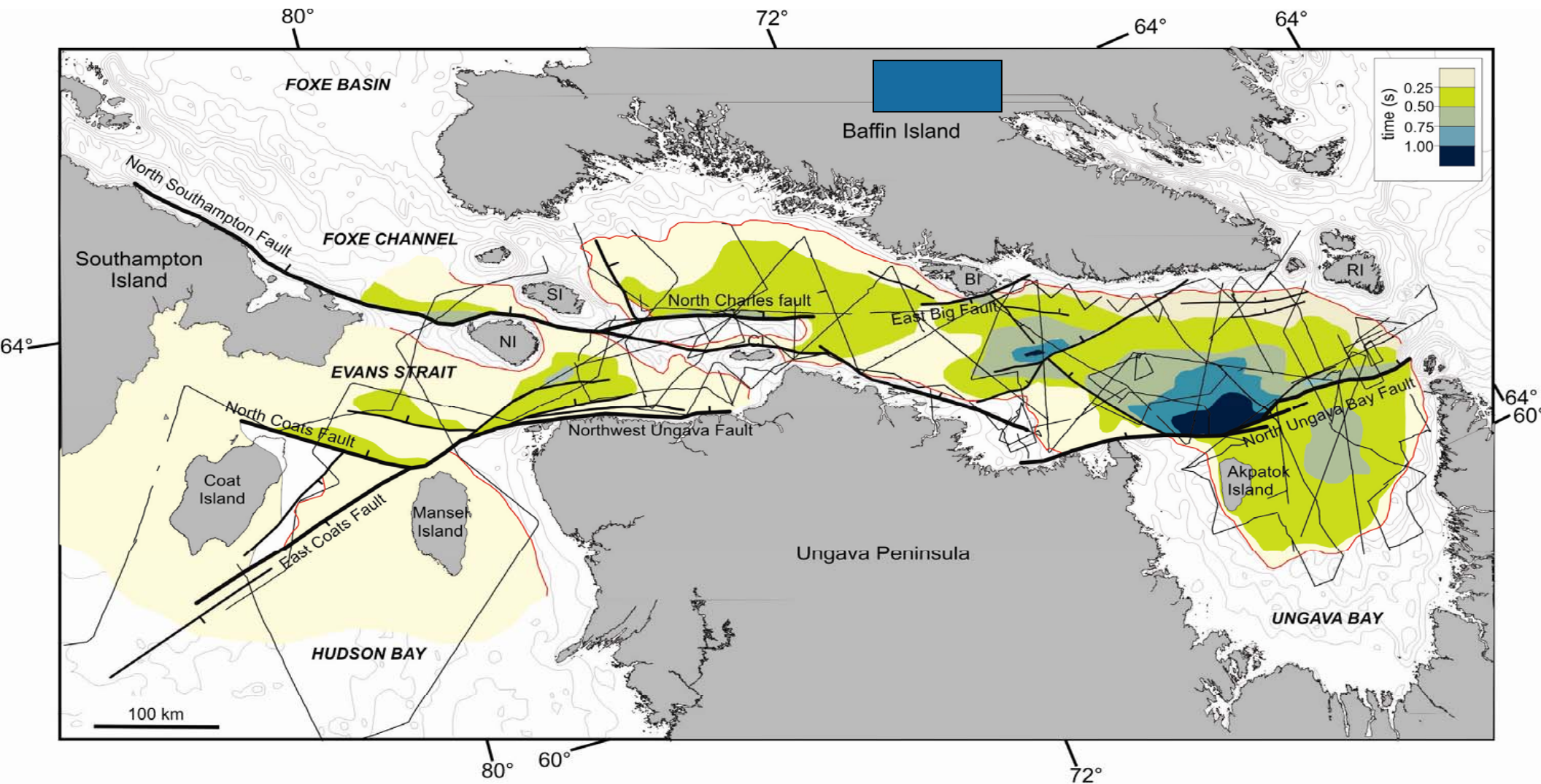
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# Oil shale geochemistry

## Cape Donovan Oil Shales, Southampton Island

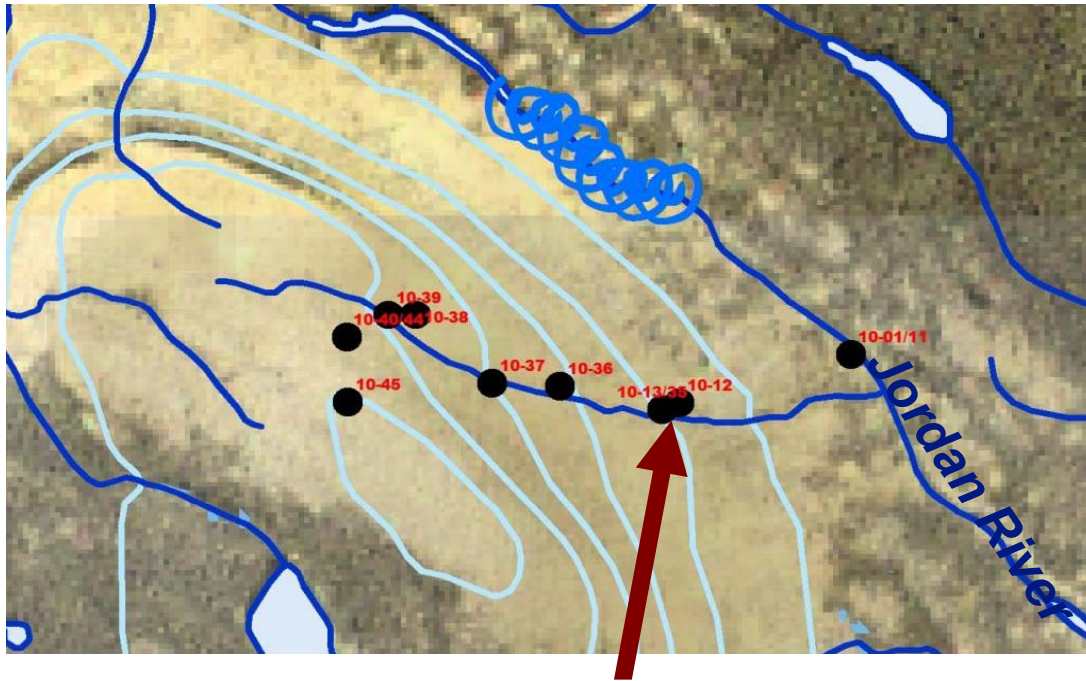


# Baffin Island – High TOC source rock



Pinet et al., Figure 6





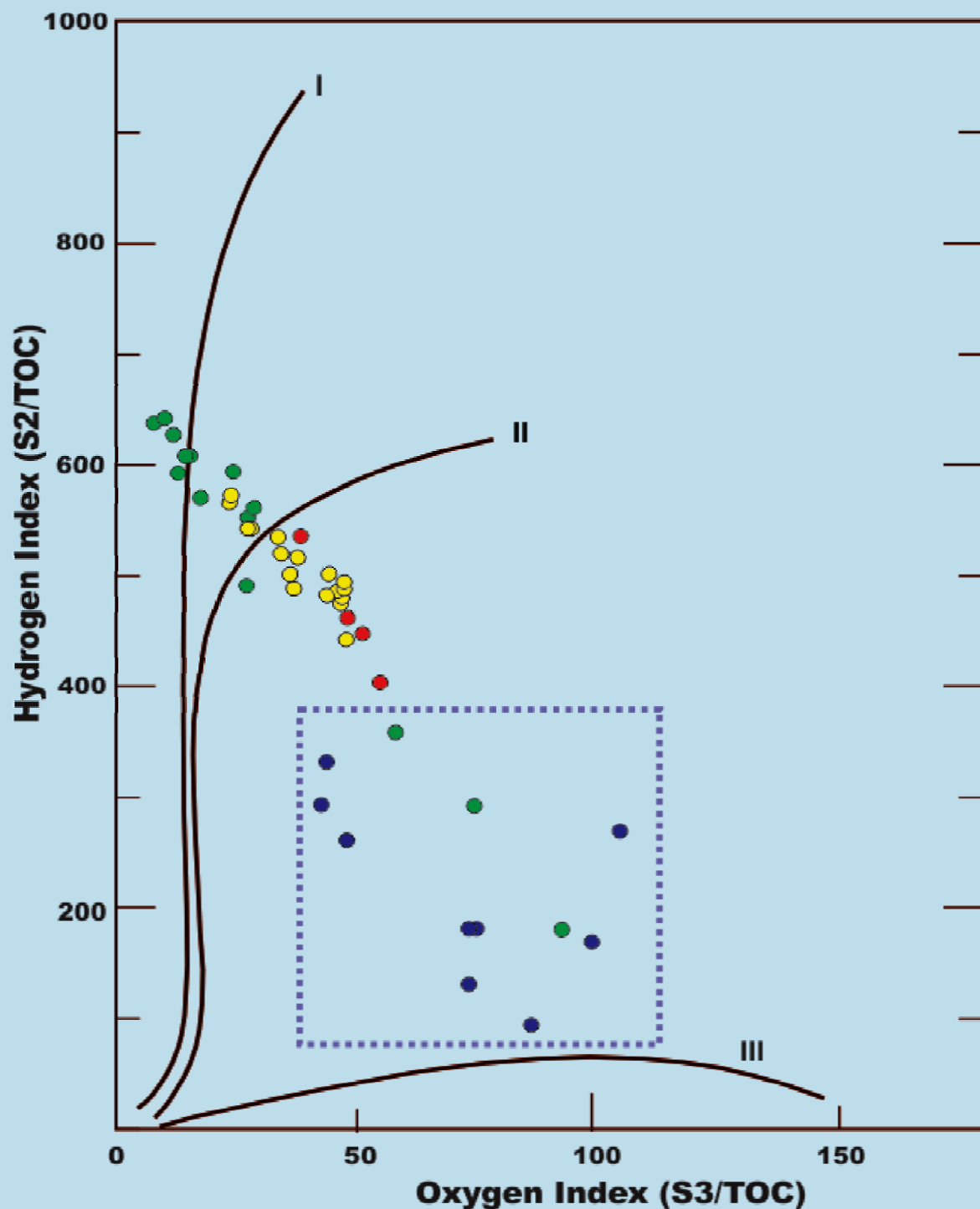
11 oil shale samples  
from outcrop of lower  
Amadjuak Fm along a  
stream perpendicular to  
Jordan River

TOC = 1.68%–12.97%  
Average TOC = 7.79%  
Tmax = 421-425

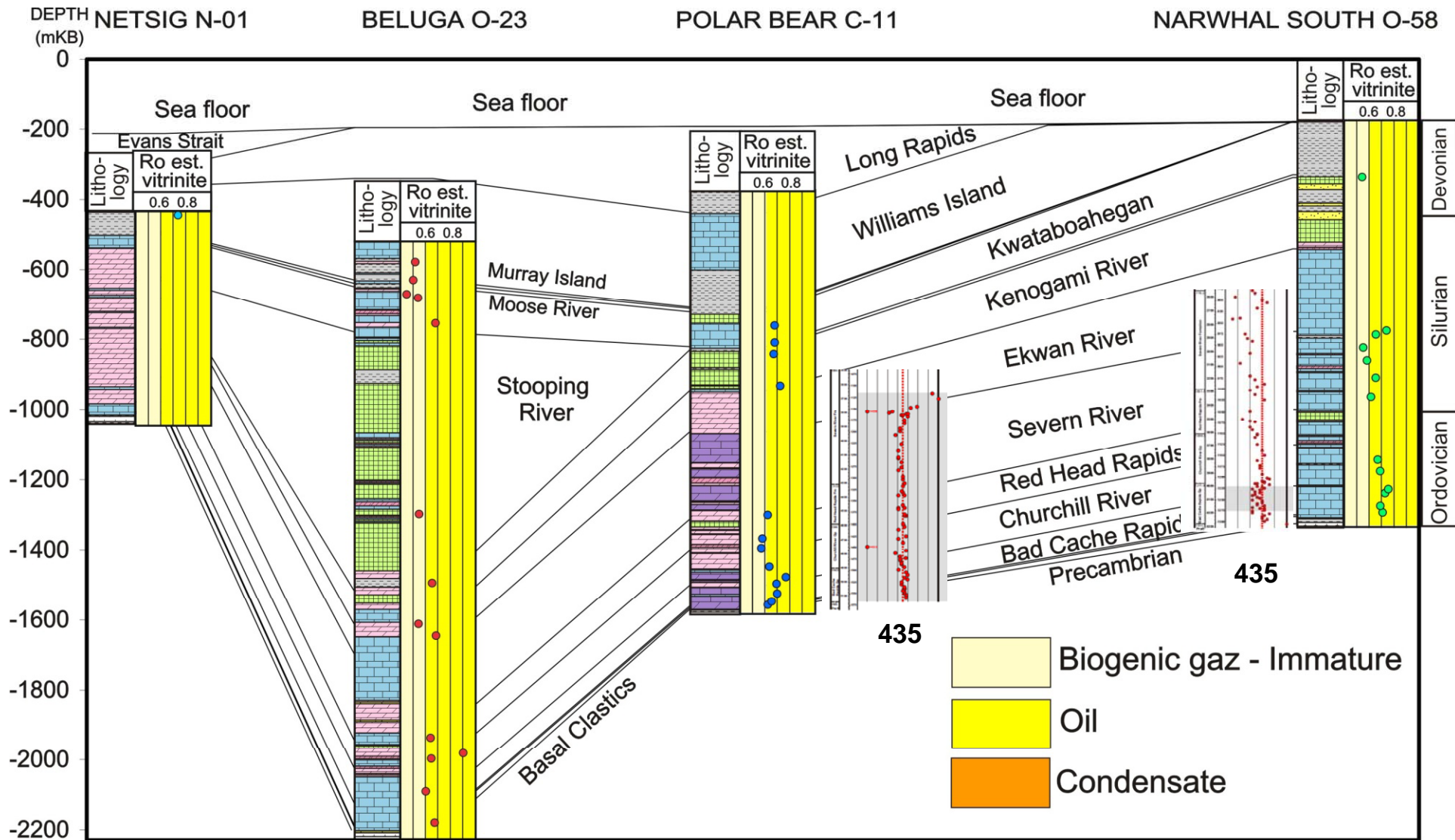


- shale samples from outcrop at Jordan River
- shale samples from outcrop at Amadjuak Lake
- oil shale rubble samples from various localities
- argillaceous limestone rubble samples from various localities

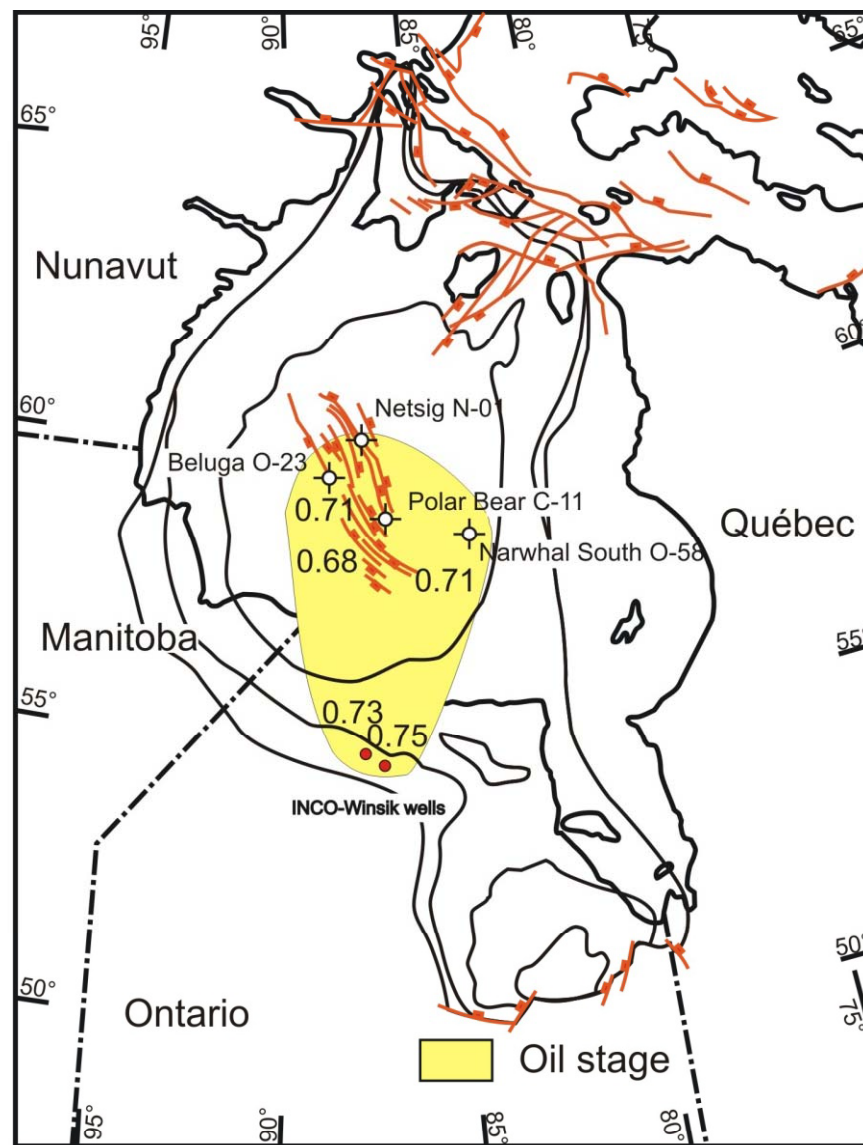
□ TOC < 1%



# Organic matter reflectance



# Regional maturation of Upper Ordovician source rock



# HYDROCARBON SYSTEM ELEMENTS

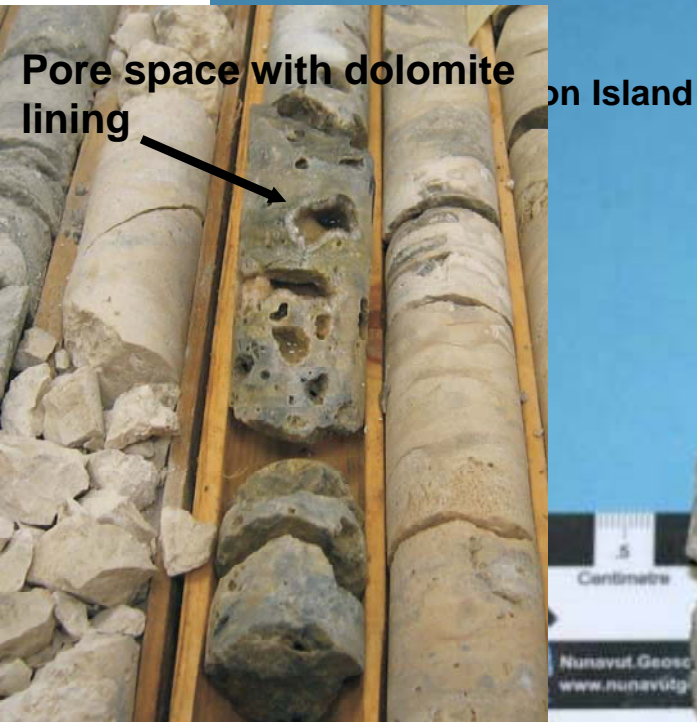
## 2. RESERVOIRS

Nature and seismic expression



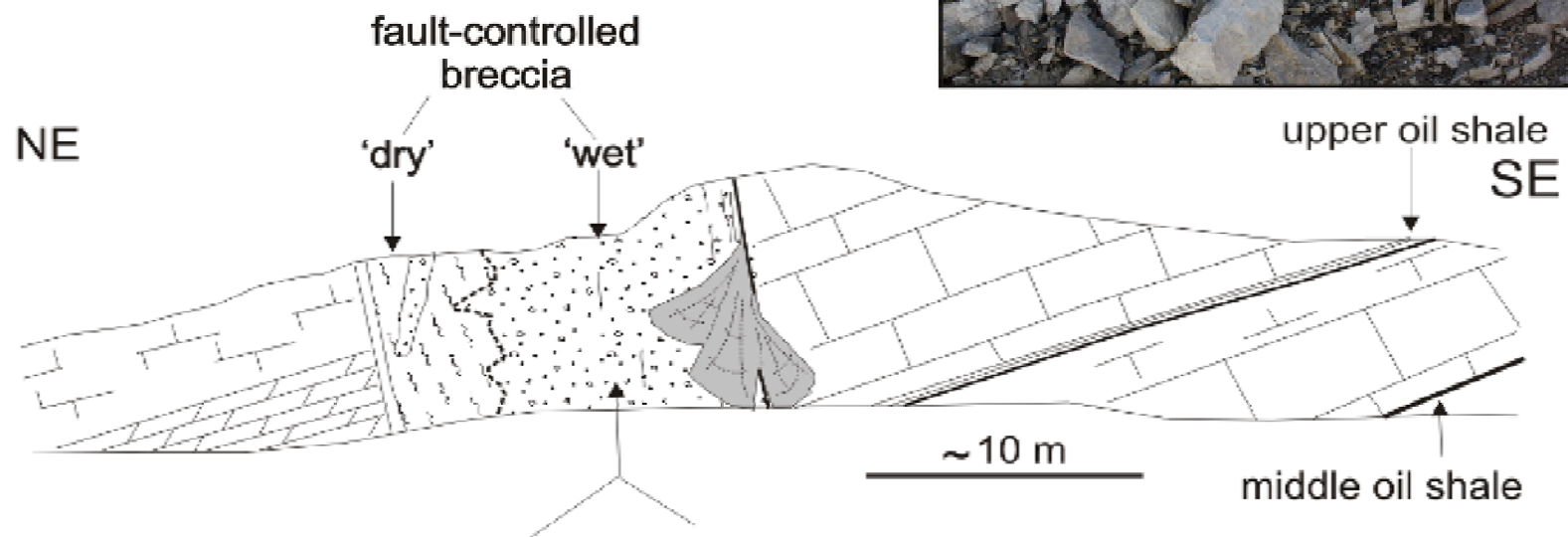
# Potential hydrothermal dolomites

## The most prolific play in the Michigan Basin



# Significant HTD outcrops North Southampton Island

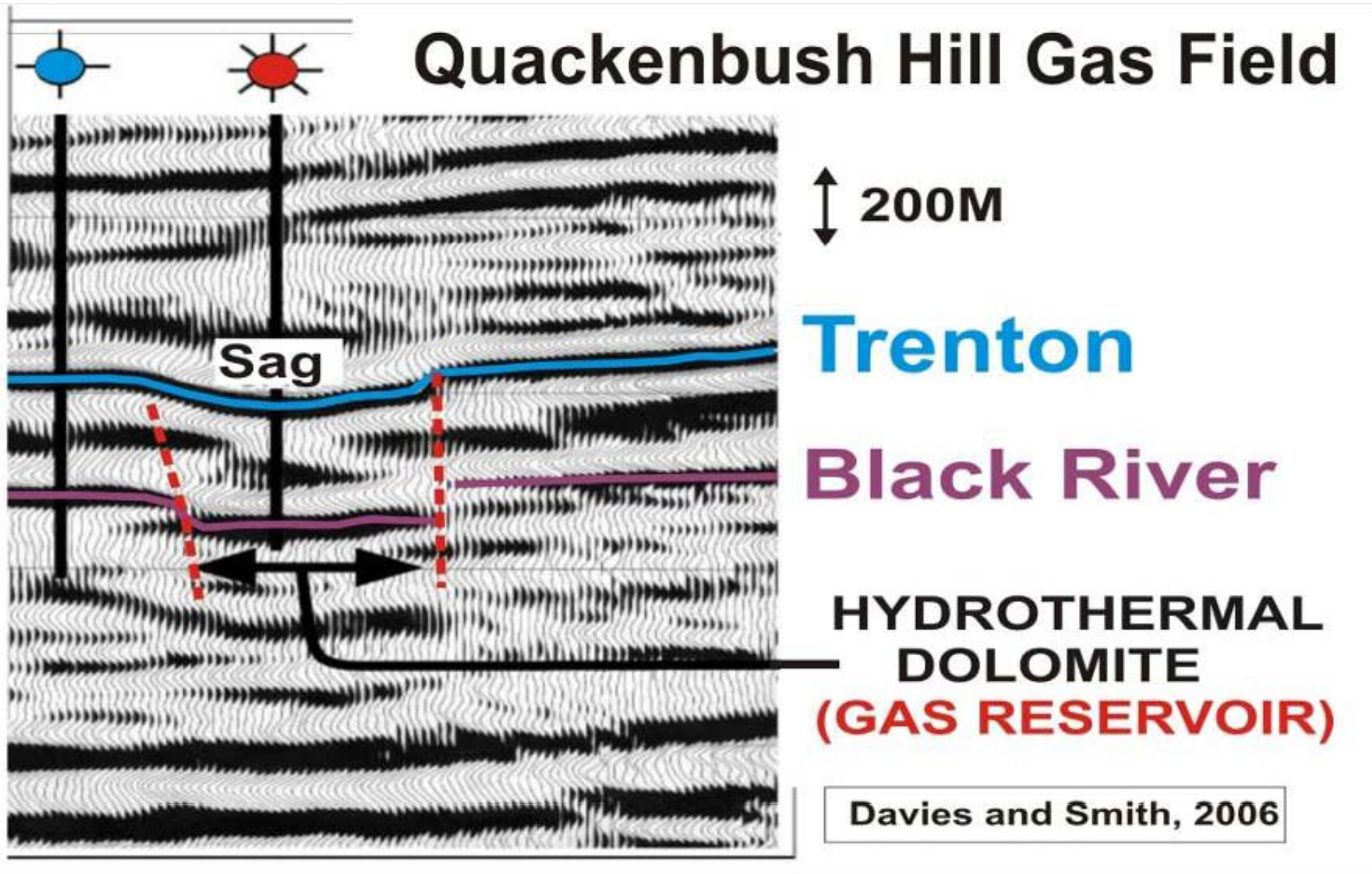
## Cape Donovan



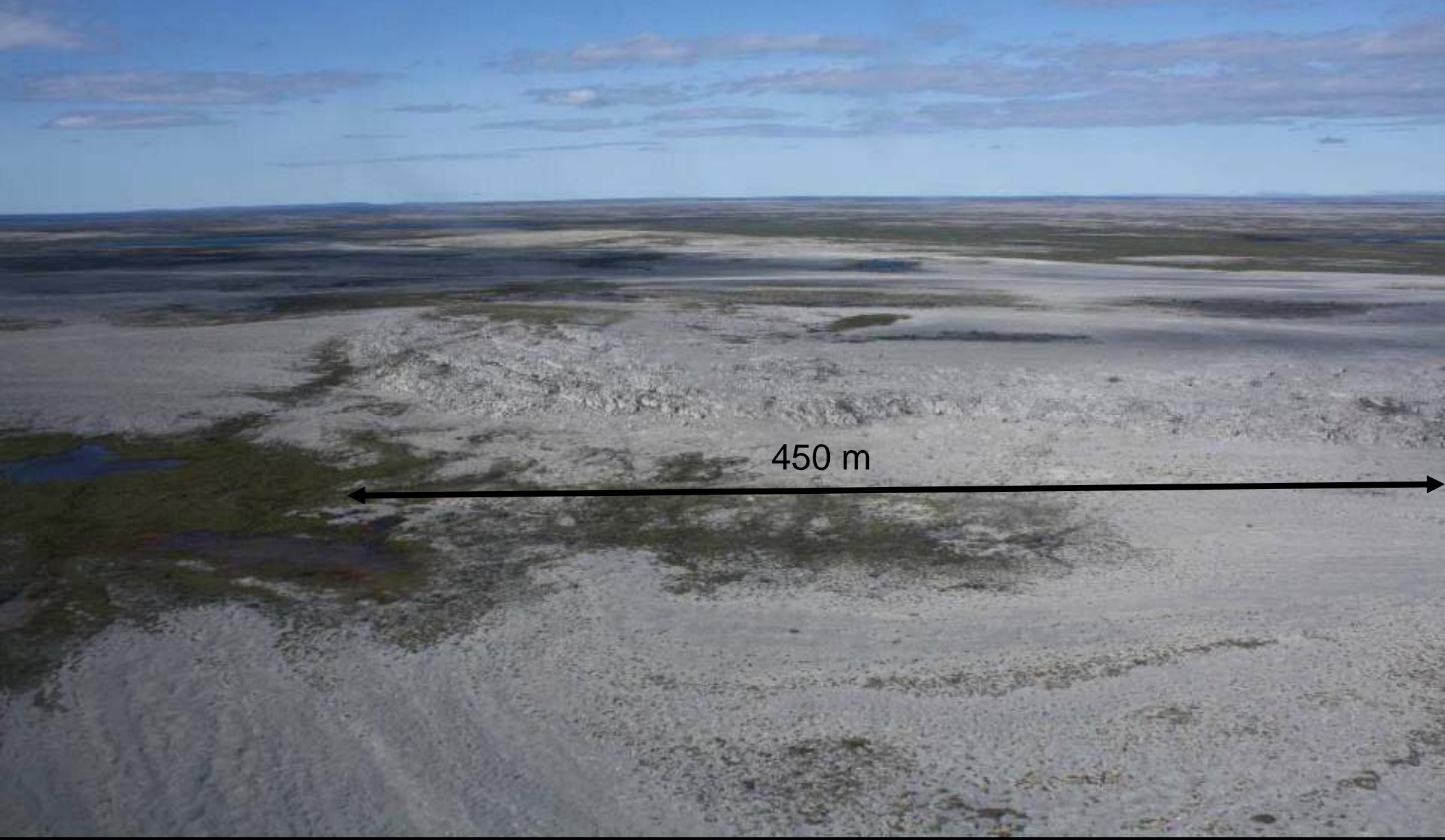
Lavoie et al. 2011

If HTD, could these be seismic sags?

## Quackenbush Hill Gas Field



# Ordovician reef – Red Head Rapids

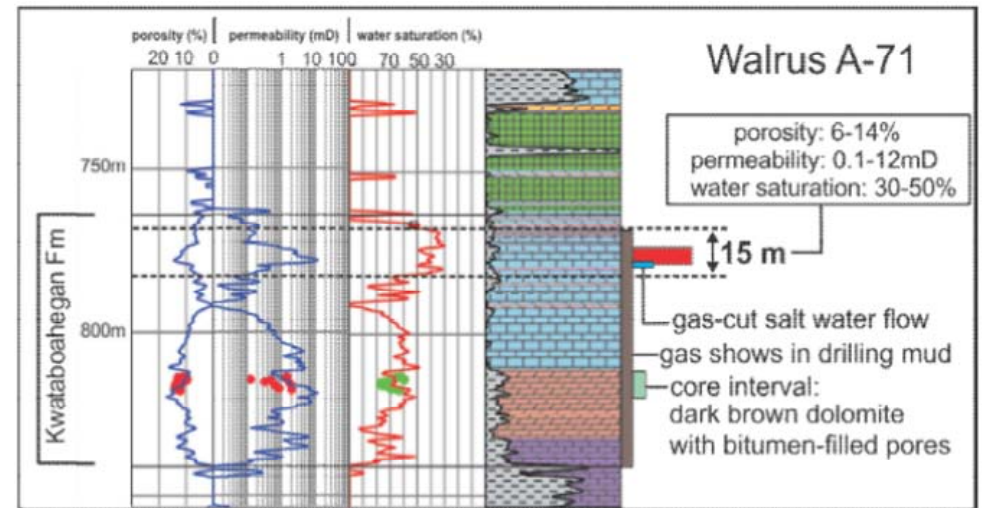
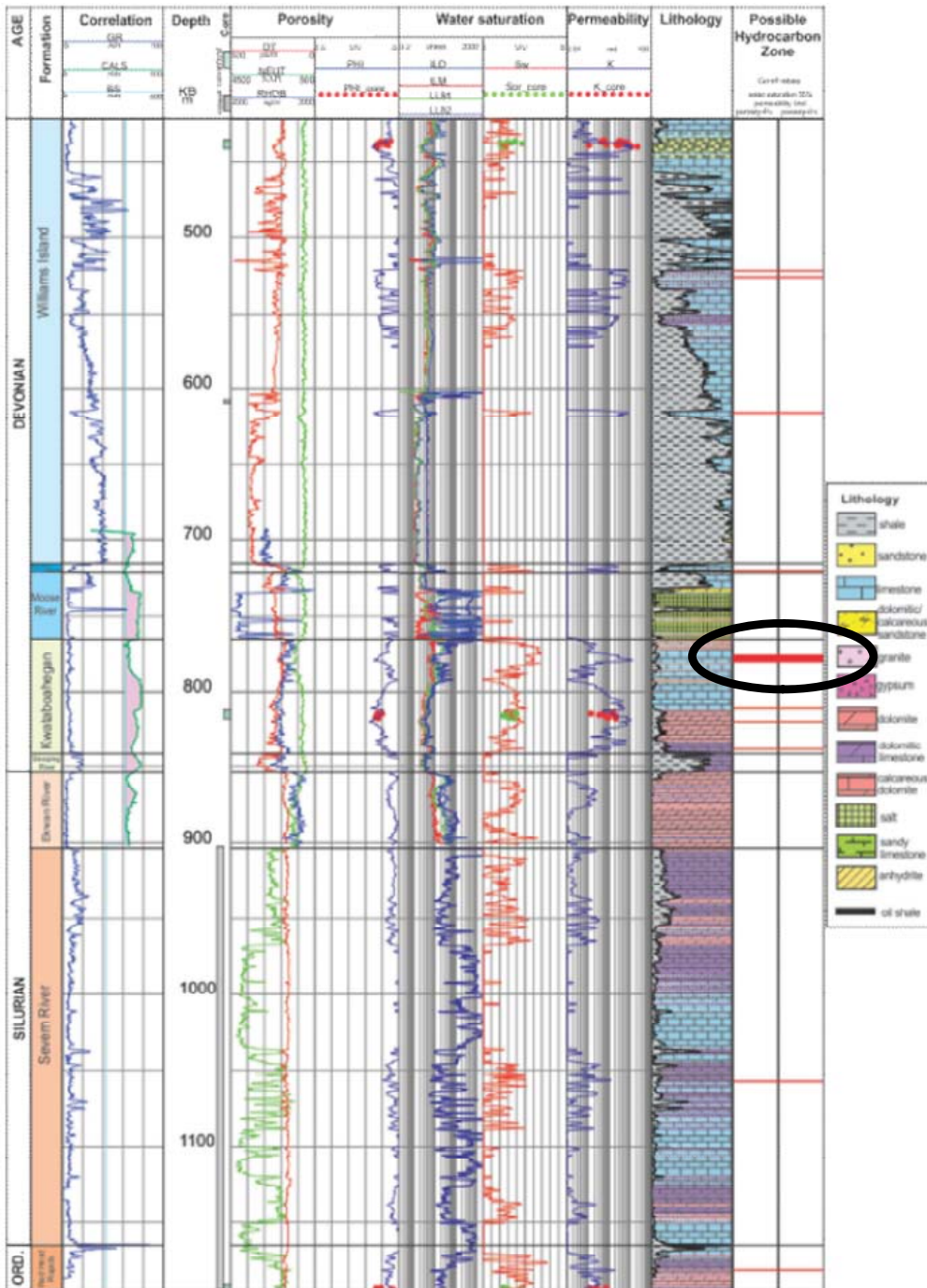


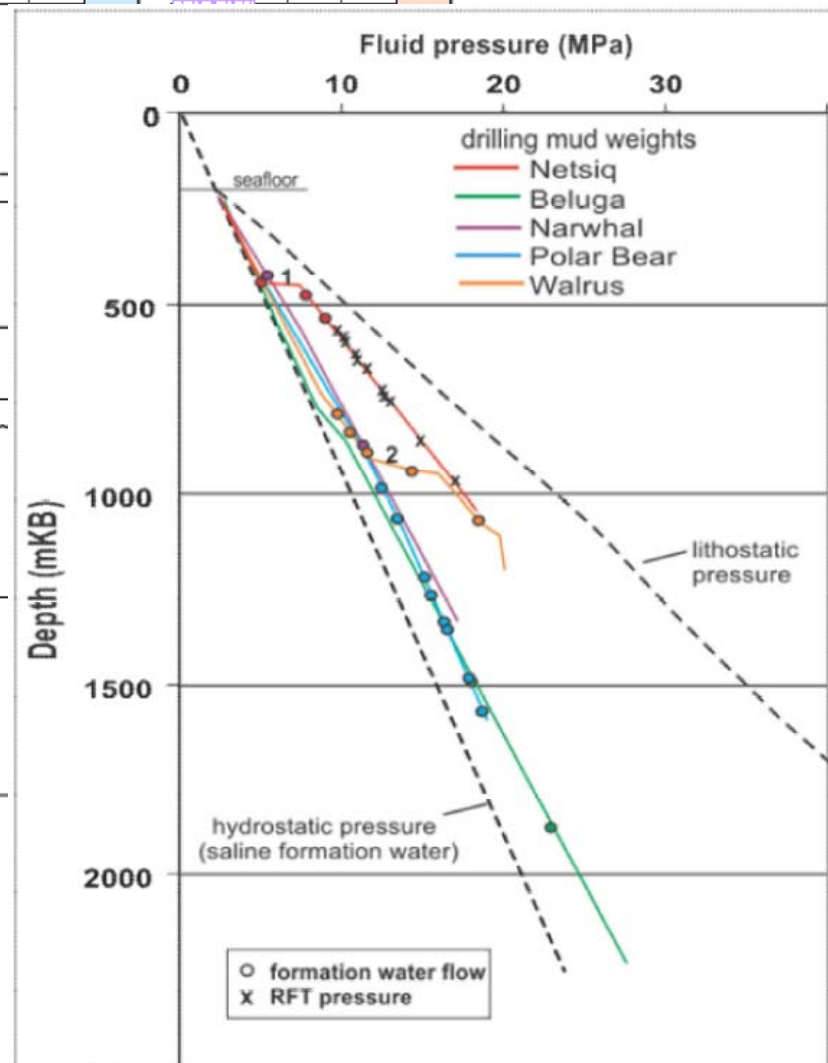
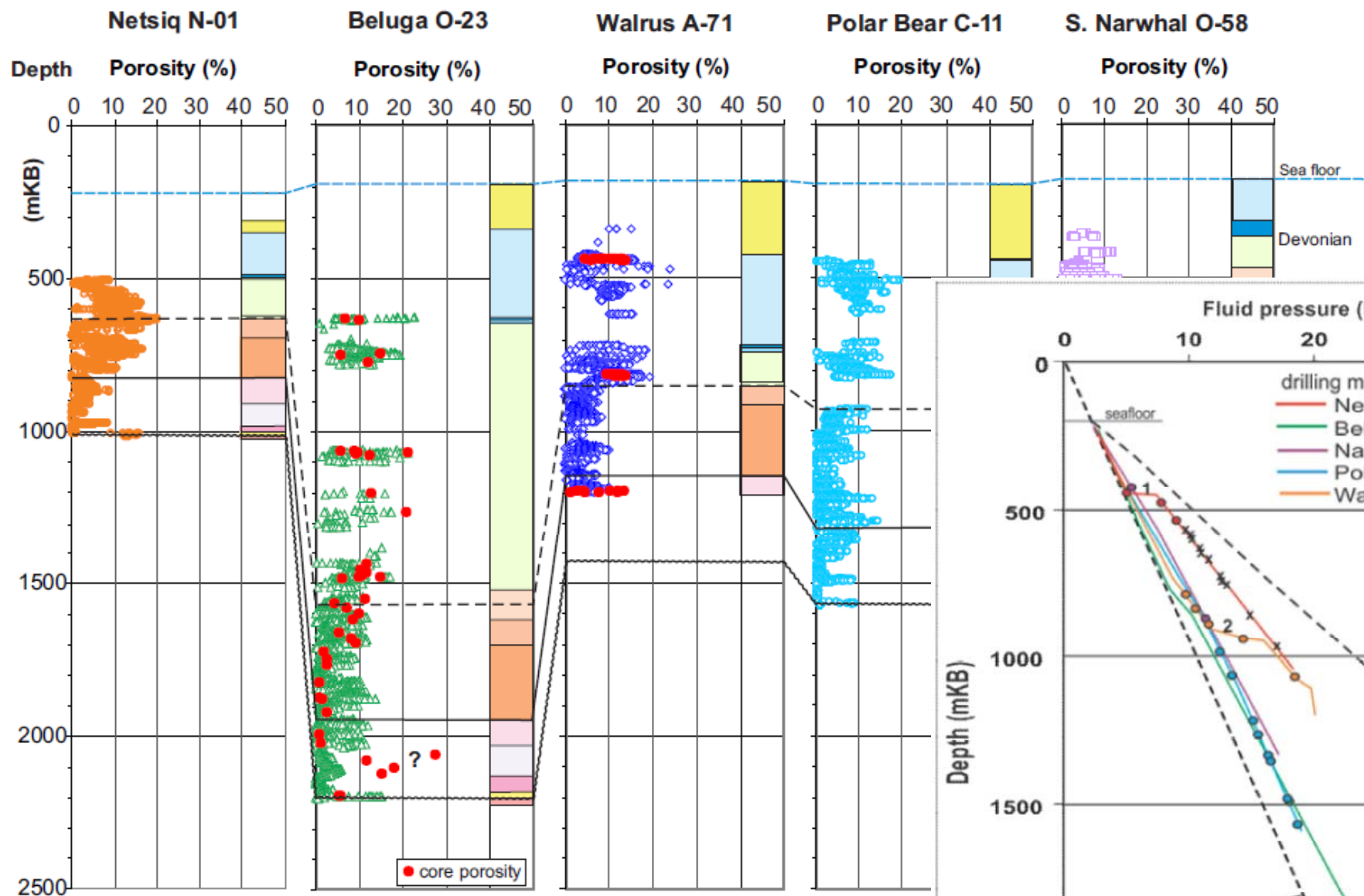
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# Petrophysical analyses of reservoir potential





Porosity with depth  
and pressure regimes (Hu and Dietrich, 2012)

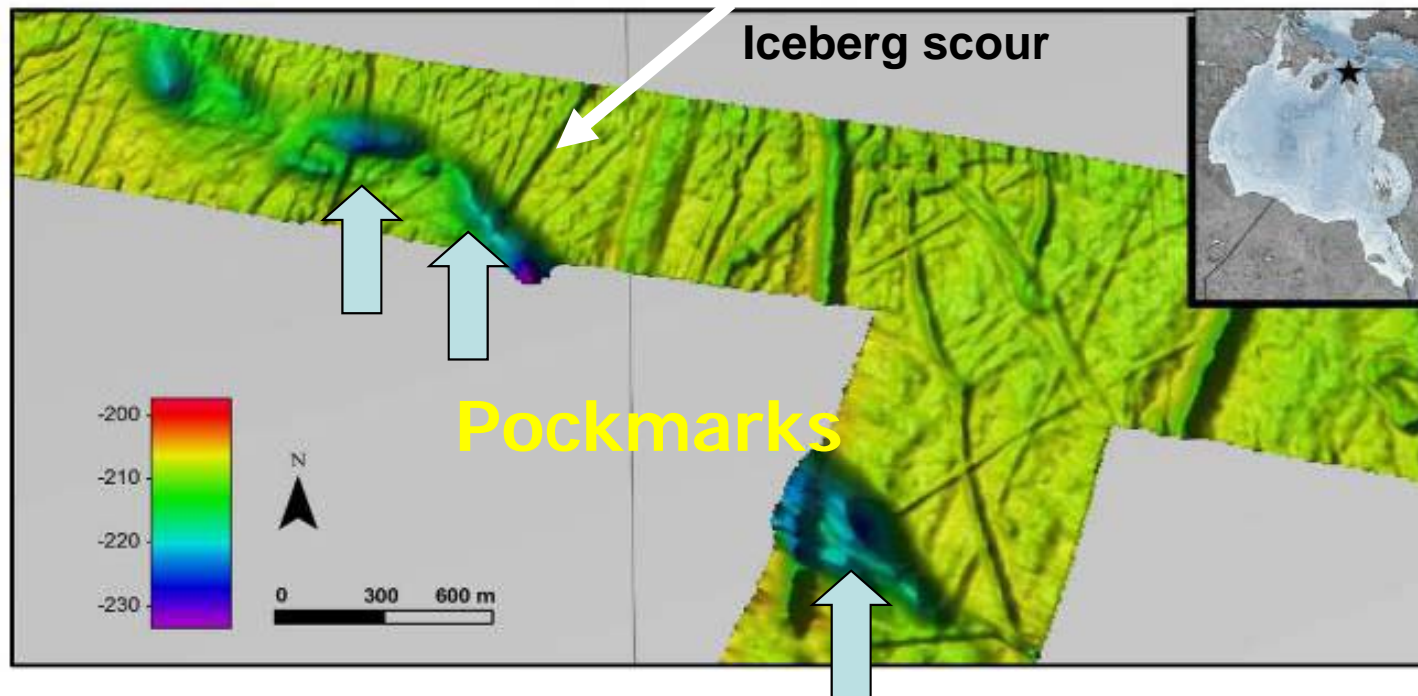
# HYDROCARBON SYSTEM ELEMENTS

## 3. TRAPPED HYDROCARBONS Evidence for active hydrocarbon systems



# Smoking gun for hydrocarbon generation ?

## High resolution seafloor maps



Roger et al. 2011

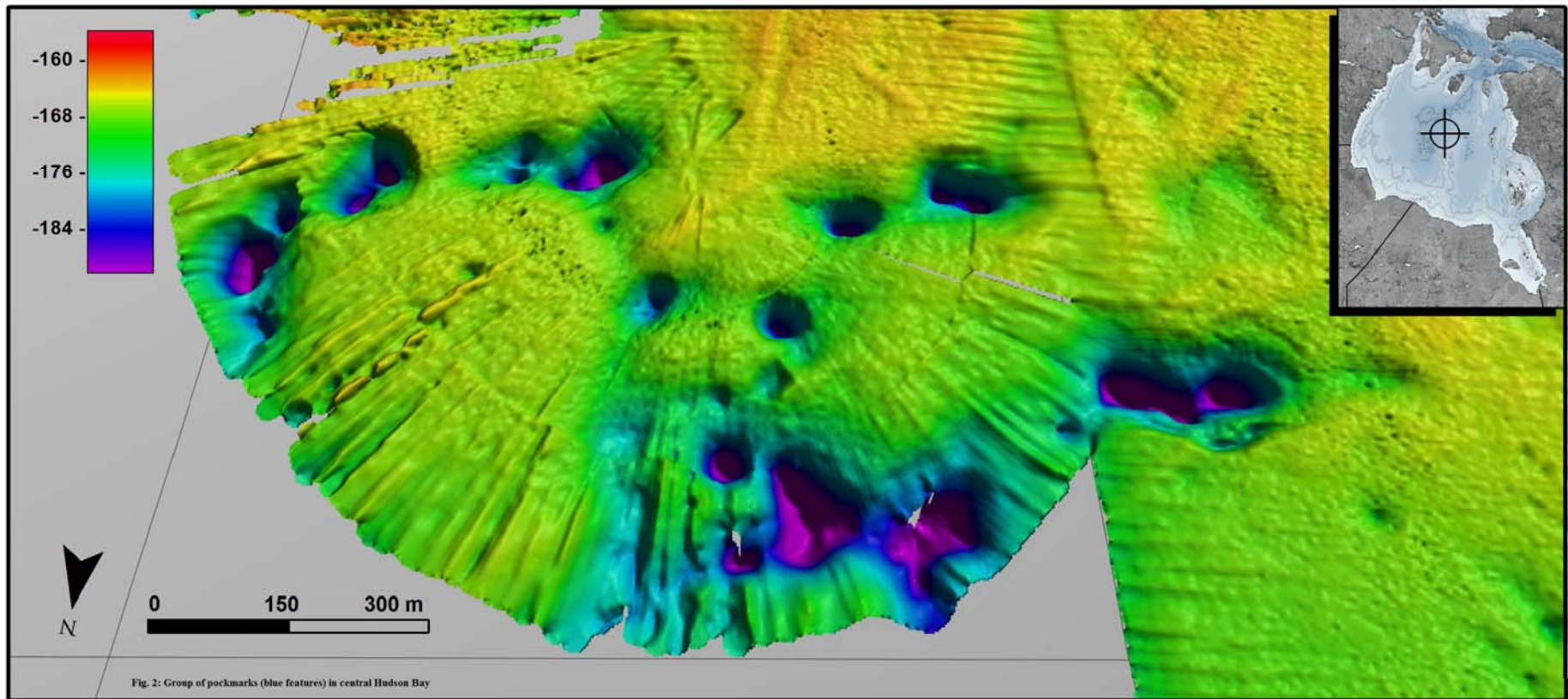


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# More pockmarks in central Hudson Bay



Roger et al. 2011



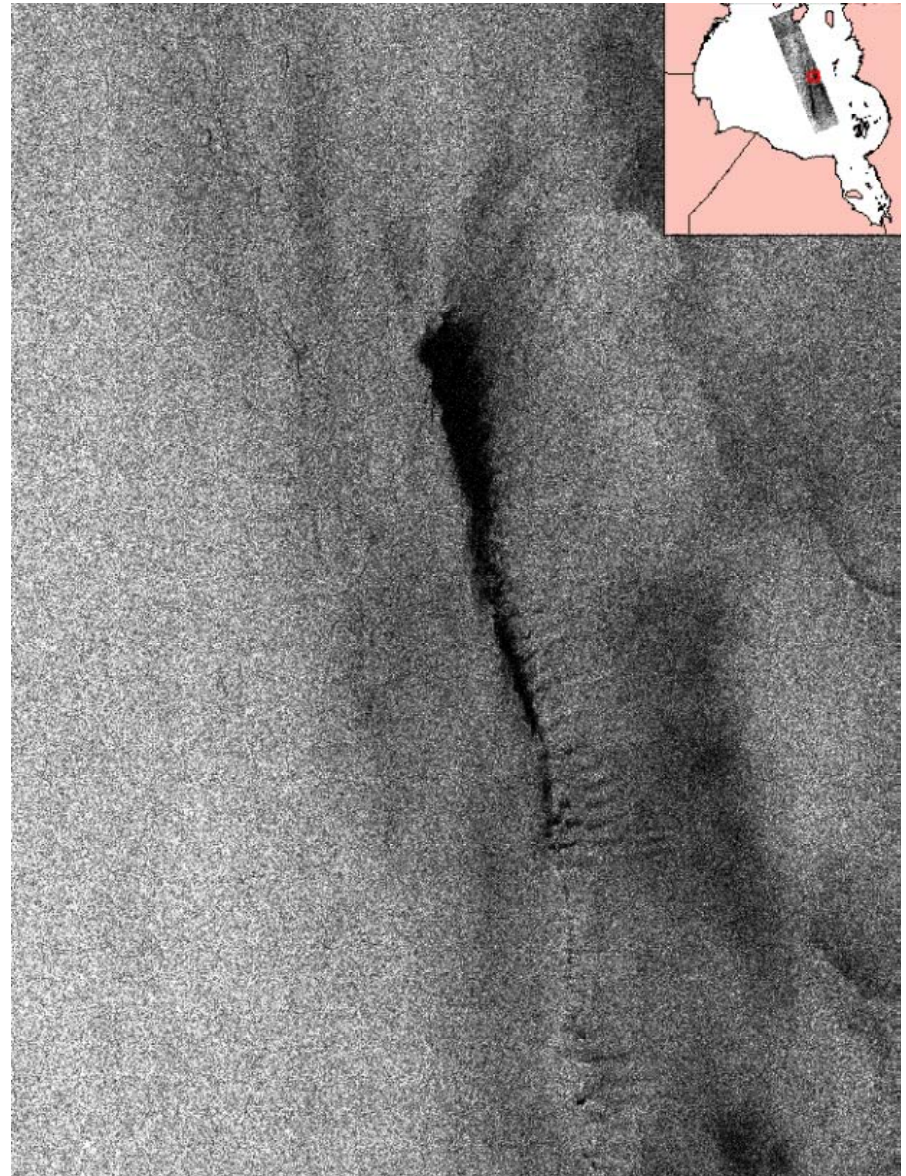
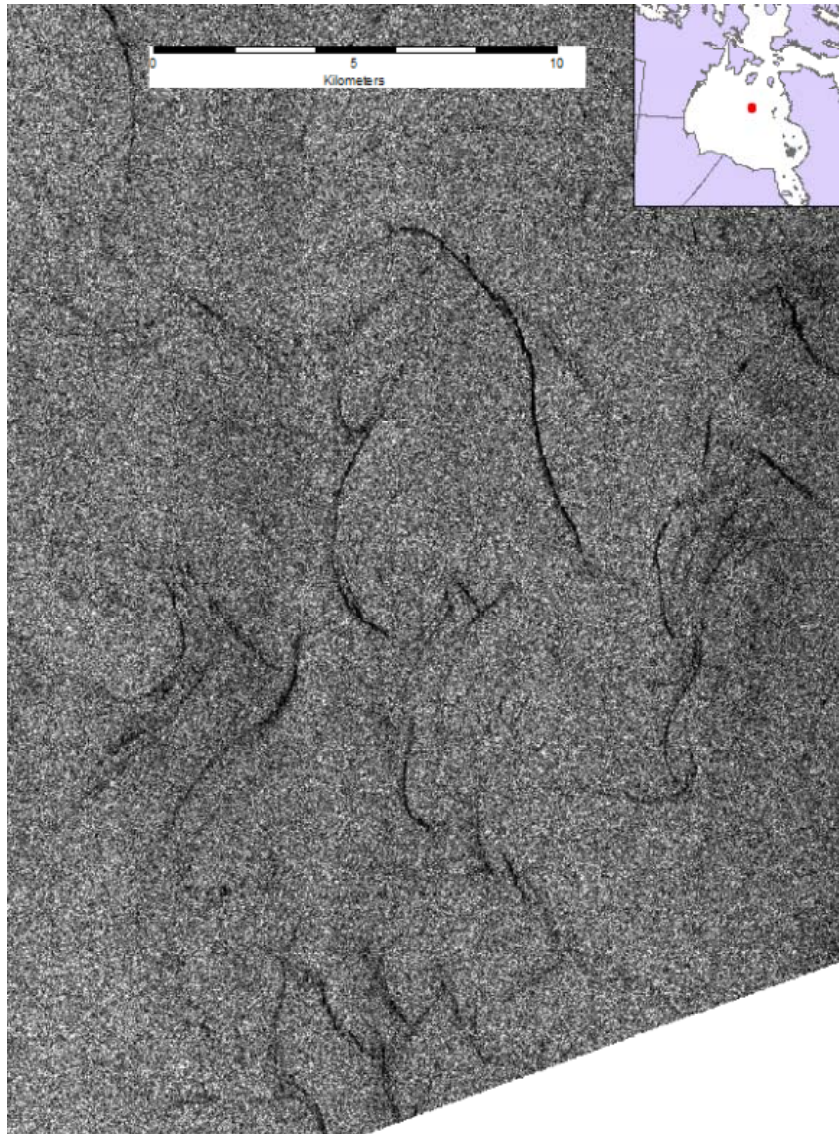
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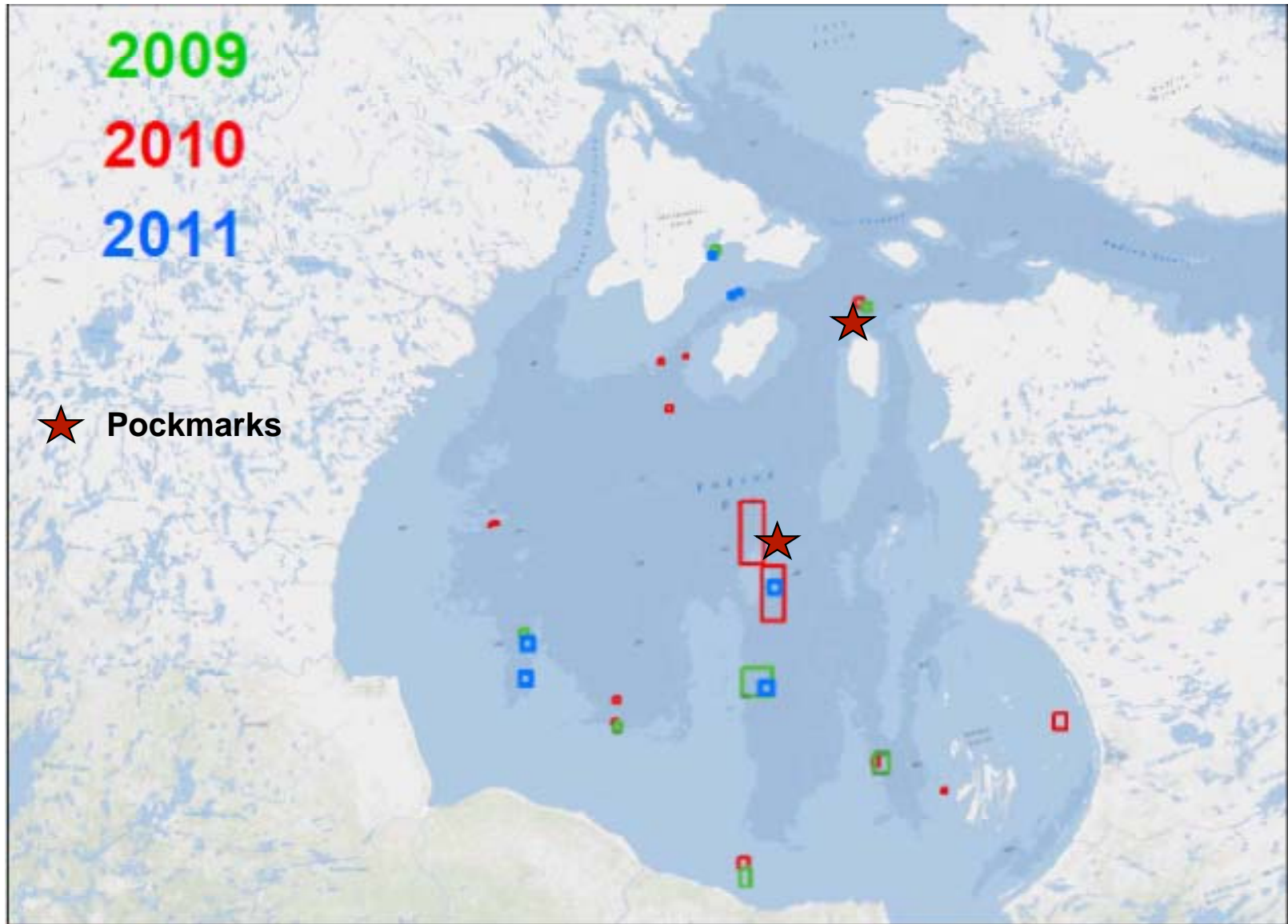
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# Oil slicks at the surface of Hudson Bay?

## RADARSAT Images



# Oil slicks at the surface of Hudson Bay?



# Conclusions

- 1. Upper Ordovician source rocks are now identified in northern Ontario. These source rocks are described all around the basin and in the wells in the central part**
- 2. New organic petrology data indicates that the Ordovician source rocks are in the oil window**
- 3. Hydrothermal dolomites, the most prolific type of reservoirs in similar basins to the south, are recognized in the field and from geochemical data. Petrophysical analyses indicate possible by-passed hydrocarbon zones and overpressure conditions in offshore wells**
- 4. Sag-like features abound on the vintage seismic data**
- 5. New seafloor map in central and northern Hudson Bay allows identification of seafloor fluid escape structures (pockmarks)**
- 6. Preliminary interpretation of RADARSAT images suggests the possible presence of oil slicks at the surface of Hudson Bay waters**



## The usual polar bear final shot Cliff NE side of Akpatok Island

